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OVERVIEW OF REMACOR'S

PRESENT BUSINESS ACTIVITIES

OCTOBER, 1997

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Extraction and Processing Industries

IRON MAKING

The primary objective of iron making is to release iron from chemical combination with oxygen, and, since the blast furnace is much the most efficient process, it receives the most attention here. Alternative methods known as direct reduction are used in over a score of countries, but less than 5 percent of iron is made this way. A third group of iron-making techniques classed as smelting-reduction is still in its infancy.

The blast furnace.

Basically, the INDEX blast furnace is a countercurrent heat and oxygen exchanger in which rising combustion gas loses most of its heat on the way up, leaving the furnace at a temperature of about 200° C (390° F), while descending iron oxides are wholly converted to metallic iron. Process control and productivity improvements all follow from a consideration of these fundamental features. For example, the most important advance of the 20th century has been a switch from the use of randomly sized ore to evenly sized sinter and pellet charges. The main benefit is that the charge descends regularly, without sticking, because the narrowing of the range of particle sizes makes the gas flow more evenly, enhancing contact with the descending solids. (Even so, it is impossible to eliminate size variations completely; at the very least, some breakdown occurs between the sinter plant or coke ovens and the furnace.)

Structure.

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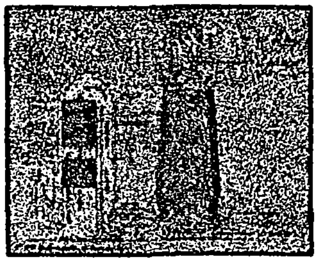

Figure 24: Schematic diagram of modern blast furnace (right) and hot-blast stove (left).

The furnace itself is a tall, vertical shaft that consists of a steel shell with a refractory lining of firebrick and graphite. Five sections can be identified (see Figure 24). At the bottom is a parallel-sided hearth where liquid metal and slag collect, and this is surmounted by an inverted truncated cone known as the bosh. Air is blown into the furnace through tuyeres, water-cooled nozzles made of copper and mounted at the top of the hearth close to its junction with the bosh. A short vertical section called the bosh parallel, or the barrel, connects the bosh to the truncated upright cone that is the stack. Finally, the fifth and topmost section, through which the charge enters the furnace, is the throat. The lining in the bosh and hearth, where the highest temperatures occur, is usually made of carbon bricks, which are manufactured by pressing and baking a mixture of coke, anthracite, and pitch. Carbon is more resistant to the corrosive action of molten iron and slag than are the aluminosilicate firebricks used for the remainder of the lining. Firebrick quality is measured by the alumina ($Al_2 0_3$) content, so that bricks containing 63 percent alumina are used in the bosh parallel, while 45 percent alumina is adequate for the stack.

Until recently, all blast furnaces used the double-bell system to introduce the charge into the stack. This equipment consists of two cones, called bells, each of which can be closed to provide a gas-tight seal. In operation, material is first deposited on the upper, smaller bell, which is then lowered a short distance to allow the charge to fall onto the larger bell. Next, the small bell is closed, and the large bell is lowered to allow the charge to drop into the furnace. In this way, gas is prevented from escaping into the atmosphere. Because it is difficult to distribute the burden evenly over the furnace cross section with this system, and because the abrasive action of the charge causes the bells to wear so that gas leakage eventually occurs, more and more furnaces are equipped with a bell-less top, in which the rate of material flow from each hopper is controlled by an adjustable gate and delivery to the stack is through a rotating chute whose angle of inclination can be altered. This arrangement gives good control of burden distribution, since successive portions of the charge can be placed in the furnace as rings of differing diameter. The charging pattern that gives the best furnace performance can then be found easily.

The general principles upon which blast-furnace design is based are as follows. Cold charge (mainly ore and coke), entering at the top of the stack, increases in temperature as it descends, so that it expands. For this reason the stack diameter must increase to let the charge move down freely, and typically the stack wall is displaced outward at an angle of 6° to 7° to the vertical. Eventually, melting of iron and slag takes place, and the voids between the solids are filled with liquid so that there is an apparent decrease in volume. This requires a smaller diameter, and the bosh wall therefore slopes inward and makes an angle to the vertical in the range of 6° to 9°. Over the years, the internal lines of the furnace that give it its characteristic shape have undergone a series of evolutionary changes, but the major alteration has been an increase in girth so that the ratio of height to bosh parallel has been progressively reduced as furnaces have become bigger.

For many years, the accepted method of building a furnace was to use the steel shell to give the structure rigidity and to support the stack with steel columns at regular intervals around the furnace. With very large furnaces, however, the mass is too great, so that a different construction must be used in which four large columns are joined to a box girder surrounding the furnace at a level near the top of the stack. The steel shell still takes most of the mass of the stack, but the furnace top is supported independently.

Operation.

Solid charge is raised to the top of the furnace either in hydraulically operated skips or by the use of conveyor belts. Air blown into the furnace through the tuyeres is preheated to a temperature between 900 ° and 1,350° C (1,650° and 2,450° F) in hot-blast stoves, and in some cases it is enriched with up to 25 percent oxygen. The main product, molten pig iron (also called hot metal or blast-furnace iron), is tapped from the bottom of the furnace at regular intervals. Productivity is measured by dividing the output by the internal working volume of the furnace; 2 to 2.5 tons per cubic metre (125 to 150 pounds per cubic foot) can be obtained every 24 hours from furnaces with working volumes of 4,000 cubic metres (140,000 cubic feet).

Two by-products, slag and gas, are also formed. Slag leaves the furnace by the same taphole as the iron (upon which it floats), and its composition generally lies in the range of 30-40 percent silica (SiO_2), 5-15 percent alumina (Al_2O_3), 35-45 percent lime (CaO), and 5-15 percent magnesia (MgO). The gas exiting at the top of the furnace is composed mainly of carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen (N_2); a typical composition would be 23 percent CO, 22 percent CO_2, 3 percent water, and 49 percent N_2. Its net combustion energy is roughly one-tenth that of methane. After the dust has been removed, this gas, together with some coke-oven gas, is burned in hot-blast stoves to heat the air blown in through the tuyeres. Hot-blast stoves are in effect temporary heat-storage devices consisting of a combustion chamber and a checkerwork of firebricks that absorb heat during the combustion period. When the stove is hot enough, combustion is stopped and cold air is blown through in the reverse direction, so that the checkerwork surrenders its heat to the air, which then travels to the furnace and enters via the tuyeres. Each furnace has three or four stoves to ensure a continuous supply of hot blast.

Chemistry.

The internal workings of a blast furnace used to be something of a mystery, but iron-making chemistry is now well established. Coke burns in oxygen present in the air blast in a combustion reaction taking place near the bottom of the furnace immediately in front of the tuyeres:

$$2C + O_2 \longrightarrow 2CO + \text{heat.}$$

The heat generated by the reaction is carried upward by the rising gases and transferred to the descending charge. The CO in the gas then reacts with iron oxide in the stack, producing metallic iron and CO_2:

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2.$$

Not all the oxygen originally present in the ore is removed like this; some remaining oxide reacts directly with carbon at the higher temperatures encountered in the bosh:

$$FeO + C \longrightarrow Fe + CO.$$

Softening and melting of the ore takes place here, droplets of metal and slag forming and trickling down through a layer of coke to collect on the hearth.

The conditions that cause the chemical reduction of iron oxides to occur also affect other oxides. All the phosphorus pentoxide (P_2O_5) and some of the silica and manganous oxide (MnO) are reduced, while phosphorus, silicon, and manganese all dissolve in the hot metal together with some carbon from the coke.

Direct reduction (DR).

This is any process in which iron is extracted from ore at a temperature below the melting points of the materials involved. Gangue remains in the spongelike product, known as direct-reduced iron, or DRI, and must be removed in a subsequent steelmaking process. Only high-grade ores and pellets made from superconcentrates (66 percent iron) are therefore really suitable for DR iron making.

Direct reduction is used mostly in special circumstances, often linked to cheap supplies of natural gas. Several processes are based on the use of a slightly inclined rotating kiln to which ore, coal, and recycled material are charged at the upper end, with heat supplied by an oil or gas burner. Results are modest, however, compared to gas-based processes, many of which are conducted in shaft furnaces. In the most successful of these, known as the Midrex (after its developer, a division of the Midland-Ross Corporation), a gas reformer converts methane (CH_4) to a mixture of carbon monoxide and hydrogen (H_2) and feeds these gases to the top half of a small shaft furnace. There descending pellets are chemically reduced at a temperature of 850° C (1,550° F). The metallized charge is cooled in the bottom half of the shaft before being discharged.

Smelting reduction.

The scarcity of coking coals for blast-furnace use and the high cost of coke ovens are two reasons for the emergence of this other alternative iron-making process. Smelting reduction employs two units: in the first, iron ore is heated and reduced by gases exiting from the second unit, which is a smelter-gasifier supplied with coal and oxygen. The partially reduced ore is then smelted in the second unit, and liquid iron is produced. Smelting-reduction technology enables a wide range of coals to be used for iron making.

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Extraction and Processing Industries

PRIMARY STEELMAKING

Principles.

In principle, steelmaking is a melting, purifying, and alloying process carried out at approximately 1,600° C (2,900° F) in molten conditions. Various chemical reactions are initiated, either in sequence or simultaneously, in order to arrive at specified chemical compositions and temperatures. Indeed, many of the reactions interfere with one another, requiring the use of process models to help in analyzing options, optimizing competing reactions, and designing efficient commercial practices.

Raw materials.

The major iron-bearing raw materials for steelmaking are blast-furnace iron, steel scrap, and direct-reduced iron (DRI; for the making of DRI and blast-furnace iron, see above *Iron: Iron making*). Liquid blast-furnace iron typically contains 3.8 to 4.5 percent carbon (C), 0.4 to 1.2 percent silicon (Si), 0.6 to 1.2 percent manganese (Mn), up to 0.2 percent INDEX phosphorus (P), and 0.04 percent sulfur (S). Its temperature is usually 1,400° to 1,500° C (2,550° to 2,700° F). The phosphorus content depends on the ore used, since phosphorus is not removed in the blast-furnace process, whereas sulfur is usually picked up during iron making from coke and other fuels. DRI is reduced from iron ore in the solid state by carbon monoxide (CO) and hydrogen (H_2). It frequently contains about 3 percent unreduced iron ore and 4 percent gangue, depending on the ore used. It is normally shipped in briquettes and charged into the steelmaking furnace like scrap. Steel scrap is metallic iron containing residuals, such as copper, tin, and chromium, that vary with its origin. Of the three major steelmaking processes--basic oxygen, open hearth, and electric arc--the first two, with few exceptions, use liquid blast-furnace iron and scrap as raw material and the latter uses a solid charge of scrap and DRI.

Oxidation reactions.

The most important chemical reactions carried out on these materials (especially on blast-furnace iron) are the oxidation of carbon to carbon monoxide, silicon to silica, manganese to manganous oxide, and phosphorus to phosphate, as follows:

$$2C + O_2 \longrightarrow 2CO;$$
$$Si + O_2 \longrightarrow SiO_2;$$
$$2Mn + O_2 \longrightarrow 2MnO;$$
and
$$2P + 2.5O_2 \longrightarrow P_2O_5.$$

Unfortunately, iron is also lost in this series of reactions, as it is oxidized to ferrous oxide:

$$2Fe + O_2 \longrightarrow 2FeO.$$

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The FeO, absorbed into the liquid slag, then acts as an oxidizer itself, as in the following reactions:

$$C + FeO \longrightarrow CO + Fe;$$

or

$$2P + 5FeO \longrightarrow P_2O_5 + 5Fe.$$

In the open-hearth furnace, oxidation also takes place when gases containing carbon dioxide (CO_2) contact the melt and react as follows:

$$Fe + CO_2 \longrightarrow FeO + CO;$$

or

$$C + CO_2 \longrightarrow 2CO.$$

The slag.

The INDEX products of the above reactions, the oxides silica, manganese oxide, phosphate, and ferrous oxide, together with burnt lime (INDEX calcium oxide; CaO) added as flux, form the slag. Burnt lime has by itself a high melting point of 2,570° C (4,660° F) and is therefore solid at steelmaking temperatures, but when it is mixed with the other oxides, they all melt together at lower temperatures and thus form the slag. A basic slag contains approximately 55 percent CaO, 15 percent SiO_2, 5 percent MnO, 18 percent FeO, and other oxides plus sulfides and phosphates. The basicity of a slag is often simply expressed by the ratio of CaO to SiO_2, with CaO being the basic and SiO_2 the acidic component. Usually, a basicity above 3.5 provides good absorption and holding capacity for calcium phosphates and calcium sulfides.

Removing sulfur.

The INDEX majority of sulfur, present as ferrous sulfide (FeS), is removed from the melt not by oxidation but by the conversion of calcium oxide to calcium sulfide:

$$FeS + CaO \rightarrow CaS + FeO.$$

According to this equation, desulfurization is successful only when using a slag with plenty of calcium oxide--in other words, with a high basicity. A low iron oxide content is also essential, since oxygen and sulfur compete to combine with the calcium. For this reason, many steel plants desulfurize blast-furnace iron before it is refined into steel, since at that stage it contains practically no dissolved oxygen, owing to its high silicon and carbon content. Nevertheless, sulfur is often introduced by scrap and flux during steelmaking, so that, in order to meet low sulfur specifications (for example, less than 0.008 percent), it is necessary to desulfurize the steel as well.

Removing carbon.

A INDEX very important chemical reaction during steelmaking is the oxidation of carbon. Its gaseous product, carbon monoxide, goes into the off-gas, but, before it does that, it generates the carbon monoxide boil, a phenomenon common to all steelmaking processes and very important for mixing. Mixing enhances chemical reactions, purges hydrogen and nitrogen, and improves heat transfer. Adjusting the carbon content is important, but it is often oxidized below specified levels, so that carbon powder must be injected to raise the carbon again.

Removing oxygen.

As INDEX the carbon level is lowered in liquid steel, the level of dissolved oxygen theoretically increases according to the relationship %C ×%O = 0.0025. This means that, for instance, a steel with 0.1 percent carbon, at equilibrium, contains about 0.025 percent, or 250 parts per million, dissolved oxygen. The level of dissolved oxygen in liquid steel must be lowered because oxygen reacts with carbon during solidification and forms carbon monoxide and blowholes in the cast. This reaction can start earlier, too, resulting in a dangerous carbon monoxide boil in the ladle. In addition, a high oxygen level creates many oxide inclusions that are harmful for most steel products. Therefore, usually at the end of steelmaking during the tapping stage, liquid steel is deoxidized by adding aluminum or silicon. Both elements are strong oxide formers and react with dissolved oxygen to form alumina ($Al_2 O_3$) or silica. These float to the surface of the steel, where they are absorbed by the slag. The upward movement of these inclusions is often slow because they are small (*e.g.*, 0.05 millimetre), and combinations of various deoxidizers are sometimes used to form larger inclusions that float more readily. In addition, stirring the melt with argon or an electromagnetic field often serves to give them a lift.

Alloying.

Deoxidation INDEX is also important before alloying steel with easy oxidizable metals such as chromium, titanium, and INDEX vanadium, in order to minimize losses and improve process control. Metals that do not oxidize readily, such as nickel, cobalt, molybdenum, and copper, can be added in the furnace to take advantage of high heating rates. In fact, alloying always has thermal effects on steelmaking--for example, the use of energy to heat and melt the alloying agents, or the heat of reaction or solution when they combine with other elements. Fortunately, there exists a large amount of empirical data, obtained from thousands of thermodynamic experiments, that, when supported by theoretical principles, allows steelmakers to predict such temperature changes.

Most alloys are added in the form of INDEX ferroalloys, which are iron-based alloys that are cheaper to produce than the pure metals. Many different grades are available. For example, ferrosilicon is supplied with levels of 50, 75, and 90 percent silicon and with varying levels of carbon and other additions.

Removing hydrogen and nitrogen.

Also INDEX important INDEX for steelmaking is the absorption and removal of the two gases hydrogen and nitrogen. Hydrogen can enter liquid steel from moist air, damp refractories, and wet flux and alloy additions. It causes brittleness of solidified steel--especially in large pieces, such as heavy forgings, that do not permit the gas to diffuse to the surface. Hydrogen can also form blowholes in castings. Nitrogen does not move into and out of liquid steel as easily as hydrogen, but it is well absorbed by liquid steel in the high-temperature zones of an electric arc or oxygen jet, where nitrogen molecules (N_2) are broken up into atoms (N). Like hydrogen, nitrogen substantially decreases the ductility of steel.

Refractory liner.

Basic INDEX steelmaking takes place in containers lined with basic refractories. These may be bricks or ram material made of highly stable oxides, such as magnesite, alumina, or the double oxides chrome-magnesite and dolomite. It is desirable that the refractories not participate in the steelmaking reactions, but unfortunately they do erode and corrode. Refractory bricks are produced in all shapes and grades by a highly specialized industry.

Testing.

Testing and sampling are an important part of liquid steelmaking. They are carried out by mechanized and often automated facilities, which immerse lances that are equipped with sensors for rapid computation of temperature and dissolved carbon, oxygen, and hydrogen. Test lances also take samples for analysis in laboratories. All results are usually fed automatically into a process-control computer.

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Basic oxygen steelmaking.

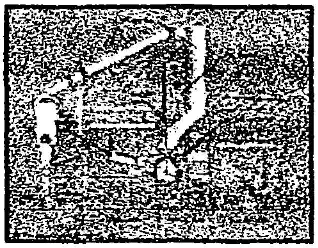

Figure 27: A basic oxygen furnace shop.

More than half the world's steel is produced in the basic oxygen process (BOP), which uses pure oxygen to convert a charge of liquid blast-furnace iron and scrap into steel. The basic oxygen furnace (BOF) is a refractory-lined, tiltable converter into which a vertically movable, water-cooled lance is inserted to blow oxygen through nozzles at supersonic velocity onto the charge (see Figure 27). The use of pure oxygen at high flow rates results in such fast oxidation of the elements contained in blast-furnace iron that only about 20 minutes are required per heat--*i.e.*, to refine one charge. Converters vary in size and are operated for heats ranging from 30 to 360 tons.

The charge.

When oxygen contacts blast-furnace iron, a great amount of heat is released by the ensuing exothermic reactions, especially the oxidation of silicon to silica, so that using only blast-furnace iron would result in a liquid steel temperature too high for casting. Therefore, before the hot metal is added, a specific amount of scrap is charged into the furnace. Melting this scrap consumes about 340 kilocalories per kilogram, effectively cooling the process. A typical BOP charge, therefore, consists of about 75 percent liquid iron and 25 percent scrap. This requires a reliable supply of low-cost iron with a uniform chemical composition, which is attainable only by keeping the operating condition of a blast furnace as constant as possible; this in turn requires a consistent iron consumer. There are also certain iron properties--for example, the silicon and sulfur content--that are selected to optimize the blast furnace and BOF operations and to produce steel at minimal cost. Such interdependence requires that blast furnaces and BOFs work within a well-integrated operating system.

The furnace.

The basic oxygen converter is a cylindrical vessel with an open cone on top. For the largest converters, those that make 360-ton heats, the shell is about 8 metres in diameter and 11 metres high. The shells are built of heavy steel plates and sit in a trunnion ring so that the converter may be rotated for charging, testing, tapping, and slag-off. The lining, normally made of magnesite bricks, has different thickness and brick quality in certain zones, depending on the wear at each location. Total lining thickness of large converters exceeds one metre. The taphole is in the upper zone of the converter, right under the cone.

Oxygen lances are large, multiwall tubes that, on large converters, are about 300 millimetres in diameter and 21 metres long. Their tips have three to five nozzles, directed slightly outward, which produce the supersonic jets of oxygen. Proper water cooling of these lances is crucial. Special lance cranes, as shown in Figure 27, move the lance up and down and adjust its distance from the steel bath. The lances last for about 150 heats before their tips have to be replaced.

BOFs are equipped with huge off-gas systems in order to avoid gas leakage into the shop and to ensure proper cleaning of the gases before they are discharged into the atmosphere. Off-gas emerges from the converter mouth at about 1,650° C (3,000° F). It consists of about 90 percent carbon monoxide and 10 percent carbon dioxide, and it also contains ferrous oxide dust, which forms in the high-temperature zone of the oxygen jet. Two off-gas systems are in use: the full combustion and the suppressed combustion.

In the full-combustion system, off-gas is burned above the mouth of the converter with excess air, and both physical and chemical heat are utilized in a boiler or hot-water system incorporated in the hood and vertical offtakes. A large venturi scrubber or electrostatic precipitator then cleans the cooled off-gas. During the blow of a large converter, about 10,000 cubic metres (350,000 cubic feet) of off-gas is moved per minute through full-combustion apparatus by exhaust fans, and about 0.7 kilogram of iron oxide dust is collected per ton of steel.

In the other system, the suppressed-combustion system, a ring-shaped hood is lowered onto the converter mouth before the blow, keeping air away from the hot off-gases. This means that they are not burned and that their chemical heating value of about 3,000 kilocalories per cubic metre is preserved. The gas is cleaned, collected in gas holders, and used at other locations. Though this system is more complicated, it is much smaller, because off-gases are cooler and there is less to be handled and processed.

BOFs are housed in huge buildings sometimes 80 metres high to accommodate the long lance, the off-gas system, and gravity-type feeding equipment. Heavy cranes, long conveyor belts, and railroad tracks assure prompt supply of raw material to the converters and fast removal of liquid steel and slag from the BOF.

The process.

Making a heat begins with an inspection of the refractory lining, with the converter in a turned-down position. Sometimes a laser contour instrument is used to determine the remaining lining thickness. With the converter tilted at about 45°, scrap is then charged into the furnace by heavy cranes or special charging machines that drop one or two large boxes full of scrap through the converter mouth. Hot metal is poured into the converter by a special iron-charging INDEX ladle (see Figure 28); this ladle receives the iron at a transfer station from transport ladles, which bring the iron from the blast furnace. Many plants lower the sulfur content of the iron just before it is charged into the converter by injecting a lime-magnesium mixture or calcium carbide or both into the charging ladle. Any blast-furnace slag and slag formed during **desulfurization** is skimmed off before the iron is charged.

Owing to predictable losses during the oxygen blow, there is always more iron and scrap charged than steel produced; for example, 1,080 kilograms of raw material may yield 1,000 kilograms of liquid steel, for a metallic yield of 92.6 percent. Chemical compositions, temperatures, and charging weights of the iron are often fed automatically into a control computer. For blowing, the converter is placed in an upright position, oxygen is turned on, and the lance is lowered. Oxygen flow rates, lance height, and lime additions are often controlled automatically. The flow rates of oxygen at large converters exceed 800 cubic metres per minute, and oxygen consumption is about 110 cubic metres per ton of steel. Usually, about 70 kilograms of pebble-sized burnt lime is added per ton of steel early in the blow; this combines with silica and other oxides to form about 150 kilograms of slag per ton of steel. Adding burnt dolomite

(CaO· MgO) results in a magnesia (MgO) content in the slag of about 6 percent, thereby decreasing slag corrosion of the magnesite lining. Lime quality is of great importance in BOF operations, and special lime kilns are used to burn a high grade of limestone.

The oxidation reactions in the converter become violent at the highest rate of carbon removal--that is, when all the silicon is gone--about eight minutes into the blow. At this point oxygen reacts mainly with carbon to generate large amounts of carbon monoxide gas, which mixes with the slag. Keeping the foamy slag from overflowing the converter at the high blowing rates is an important control task. Often a small, water-cooled sensor lance, called the sublance, is immersed into the liquid steel during the end phase of the blow to check and sample the steel. Test results are automatically fed into a control computer, which predicts the end point and shuts off the oxygen when temperature and chemical composition have reached the specified level.

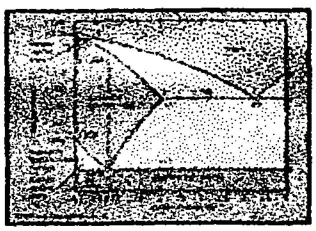

Figure 25: Iron-carbon equilibrium diagram.

Well-controlled charging conditions make it possible to tap the heat based only on the sublance test. In other cases, the converter must be turned down and the temperature and chemical composition checked manually. Sometimes burnt lime is added and a short reblow is applied in order to increase the temperature or correct the chemical composition. For tapping, the converter is rotated, and steel is poured through the taphole into a ladle sitting on a transfer car beneath the converter. The temperature of the steel at tapping is specifically selected to fit within a temperature "window" for ingot pouring or continuous casting and after all temperature losses expected during treating and holding of the steel in the ladle have been predicted. For example, a 0.1-percent-carbon steel may tap at 1,596° C, 80° C above its theoretical solidification point. Higher carbon steels would be tapped at lower temperatures, following the A-B-C liquidus line of the equilibrium diagram in Figure 25.

Aluminum or ferrosilicon are added to the ladle before or during the tap in order to lower the level of dissolved oxygen in steel. INDEX Ferromanganese is also added, since most of the manganese content of the blast-furnace iron is oxidized during the blow, leaving only about 0.1 percent in the steel--usually not enough to meet specifications.

When slag appears, the converter is rotated all the way back, and the slag is poured over the converter mouth into a slag pot. For better separation of slag from liquid steel, special taphole-closing devices such as refractory balls or nitrogen jets, as well as slag-detection devices, are often used.

BOFs have a tap-to-tap time of 30 to 45 minutes and can blow more than 30 heats per day. Large BOF shops with three converters can produce up to five million tons of liquid steel per year. Repair and maintenance are extremely important, because steel is made around the clock and there is normally only one maintenance shift per week. A converter lining lasts 1,500 to 3,000 heats, after which it is broken out and a new one installed in a mechanized bricklaying operation. Converter relining takes less than one week.

Variations.

There are a number of significant improvements, modifications, and process changes of the BOF

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steelmaking system. For example, when high-phosphorus ore is smelted in the blast furnace, and the BOF is consequently charged with a liquid iron containing more than 0.15 percent of that element, the LD-AC process can be followed, in which lime powder is injected through the lance along with oxygen for quick slag formation. A two-slag practice is then followed for sufficient phosphorus removal, with the first slag runoff being sold for fertilizer. Another variation that finds wide application is the injecting of argon (or sometimes nitrogen) into the molten charge through permeable refractory blocks in the bottom of the converter. Bottom stirring enhances chemical reactions and lowers the steel temperature at the oxygen impact area, resulting in less oxidation of iron and better yield. Another system, called the INDEX Q-BOP, uses no top lance at all, blowing oxygen, burnt-lime powder, and, when needed, argon upward through the liquid melt from several gas-cooled or oil-cooled bottom tuyeres. These tuyeres are two concentric steel tubes, with oxygen flowing from the inside annulus and gas or oil flowing through the outer annulus. Cooling of the tubes is accomplished by the endothermic heat required to break down the natural gas or oil into carbon monoxide and hydrogen.

The service life of the bottom of the Q-BOP converter is lower than that of the side wall, thus demanding additional maintenance time for bottom changing. On the other hand, bottom blowing has the advantage of generating a large contact surface among all reactants, thus improving metallurgical reactions and process control. Yield is also higher, since there is less local iron oxidation. However, less oxidation also means the release of less exothermic heat; this decreases the quantity of scrap that can be charged, which can be a cost disadvantage when the price of scrap is low. For this reason, some steel plants enhance bottom blowing with a postcombustion top lance. This is an oxygen lance with additional ports at the tip for burning carbon monoxide into carbon dioxide inside the converter. The additional heat generated by this combined blowing practice increases the potential scrap-charging rate.

Another technology for increasing scrap rates uses an oxy-fuel lance, which preheats the scrap in the converter for about 20 minutes before the liquid blast-furnace iron is added. Another scrap-increasing practice adds aluminum to the charge or melt; this releases heat as it is burned during the oxygen blow. Still another process injects coal powder through a modified oxygen lance or through special bottom tuyeres, simultaneously applying additional oxygen and using a postcombustion lance. In trial operations, this combination has resulted in scrap-charging capabilities all the way up to 100 percent; in other words, no hot metal has been charged, and the converter has become a scrap melter. Increasing scrap-charging rates helps to keep the plant operating when the supply of blast-furnace iron is limited, as, for example, during a blast-furnace reline.

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POTENTIAL NEW BUSINESS

FY 98 (Not included in forecast)

Customer	Location	Reason for Business	Start Date	Sales	Gross Profit	Probability
1. Stelco	Hamilton, Ontario	Desulf. Technology	November 1	$ 1,740,000	$ 600,000	75%
2. LTV Steel	Indiana Harbor	Desulf. Technology	November 1	2,400,000	960,000	75%
3. Dofasco	Hamilton, Ontario	Desulf. Technology	Jan/Mar	2,400,000	720,000	50%
4. Granite City Steel	St. Louis, MO	Desulf. Technology	January 1	1,800,000	720,000	50%
5. McLouth (DSC)	Detroit, MI	Si/Dephos/Desulf	April 1	1,800,000	720,000	100%
6. Nizny Tagil	Russia	Technology & Equip.	December 1	2,800,000	1,120,000	75%
7. Servestal	Russia	Technology & Equip.	January 1	6,500,000	2,600,000	75%
8. Lief International	China	Mg Prod. Technology	April	1,500,000	1,000,000	50%
		Total Potential New Business		$ 20,940,000	$ 8,440,000	

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REMACOR
AREAS OF IMPROVEMENT

The biggest area of improvement is being adequately financed. For example, last year we purchased approximately 6000 MT of magnesium for hot metal desulfurization. Because of our inability to finance large volume purchases from overseas, we have had to get trading companies involved and purchase from Reade Manufacturing Company which cost us roughly $3627 per metric ton delivered our plant. Had we had adequate financing ability, we could have purchased the 6000 MT for approximately $2919 per metric ton or a $4.25 million savings.

Furthermore, in the cost of $2919 per metric ton there is a powder manufacturing cost of $0.19 per lb. By building a new magnesium powder production facility at our Fort Erie plant, we could reduce that cost to $0.08 per lb or another annual savings on the 6000 MT of $1.46 million. Therefore, adequate working capital for the same sales, could have resulted in an additional $5.71 million in earnings.

Our cash constraints also prevent us from capitalizing on our superior technology in the steel ladle products market as we are prevented from installing the necessary production facilities at our Gary, In, Lindon, UT and Fort Erie, Ontario plant.

This is not to say that REMACOR could not improve in many areas of operations, management and marketing. However, the present inadequate working capital situation of REMACOR, if significantly improved, will by far have the most dramatic impact on increased sales and earnings.

FY 1997

PURCHASED 6000 MT OF MAGNESIUM

Average Powder Price Per MT	-	$3,627	($1.645/lb)
Market Price on Chinese Ingot Per MT	-	2,500	($1.134/lb)
Grinding Cost at Fort Erie ($0.08/lb vs $0.19/lb)	-	176	($0.08/lb)
Total Potential Savings Per MT	-	$ 951	
Total Potential Savings for FY97	-	$5,706,000	

9/30/97
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REMACOR MARKETS

Market	Market Size ($)	% Market
Desulfurization	$160 Million	26%
Steel Ladle Metallurgy	$150 Million	7%

PRODUCT/MARKET BREAKDOWN

	% of Sales
Desulfurization	75.5%
Steel Ladle Metallurgy	16.5%
Other	8.0%
	100.0%

9/30/97
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NEWS RELEASE

TO:

FOR: IMMEDIATE RELEASE

DATE: MAY 28, 1997

NEWS ABOUT: REMACOR AND USX DEVELOP A MAGNESIUM-FREE DESULFURIZING REAGENT

Through the joint technical efforts of REMACOR's process metallurgists and USX's in-house technical personnel at its Gary, IN plant, a new and extremely effective hot metal desulfurization reagent has been developed that may significantly reduce hot metal desulfurization costs. The new technology utilizes a unique knowledge of slag chemistry and hot metal injection practices to desulfurize without costly magnesium and troublesome calcium carbide. The new reagent is not combustible and is less hazardous as compared to calcium carbide and magnesium-bearing reagents. REMACOR is presently phasing in this new reagent at several steel plants which replaces its traditional magnesium-bearing desulfurization reagents. REMACOR and USX filed a patent application on the new process several months ago and plan on exploiting the new technology on a world-wide basis.

For further information, please contact:

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"It's Performance That Counts"

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AMERICAN METAL MARKET, JUNE 2, 1997

Steel and magnesium: a relationship at risk?

By BOB REGAN

NEW YORK — A hotly competitive international magnesium market could boil over in the next year or so if a new steel desulfurization product developed jointly by Remacor and USX Corp. pans out.

It doesn't use magnesium and, according to Joseph Jackman, president of West Pittsburgh-based Remacor, it could cut the steel industry's desulfurization costs enough to drive magnesium almost—but not completely—out of that business.

Steel desulfurization, which accounts for 15.8 percent of North American magnesium consumption and 13.4 percent of the Western magnesium market, has been a highly competitive market for the major Western magnesium producers and an easy target for hard cash-seeking exporters in Russia, China and Ukraine.

These three countries collectively have taken nearly 44 percent of the Western steel desulfurization market at a time when new Western magnesium smelters are crowding in.

Jackman said that Remacor and USX filed a patent application on the new process earlier this year.

In a telephone interview last week, Jackman said the new reagent has been been given its shakedown test at some steel mills—not USX facilities—and Remacor has determined that it could replace about 75 percent of the magnesium-bearing reagents used in North America, with Europe also showing sizable potential.

Jackman said the development was more of a "better mousetrap" rather than being price-driven.

If successful, could the new reagent drive magnesium all the way out of the business? "Not likely," said Jackman, "when it comes to steel with unusually high sulfur content, it would take too much of our product—and too much time—to do the job."

TO: J. R. Jackman

FROM: J. C. Amer Amer

DATE: September 26, 1997

SUBJECT: 12A at Bethlehem

As you know, Joe Macri has compiled detail statistics on our performance at Bethlehem. During the period from June 29 to September 22 on those heats which used 12A only, we treated 309,656 tons of hot metal with 2,649,908 lbs. of 12A. We invoiced Bethlehem $0.20 per lb. while our manufacturing cost was $0.109 per lb. Total sales amounted to $529,982 with a gross profit of $235,047, or 44.4%. Wow!

Joe Macri calculated that had we treated these heats with magnesium, we would have used 284,972 lbs. of magnesium and 981,575 lbs. of lime. Using a cost of magnesium powder at the current level of $1.45, total product cost would have been $469,729. The product cost of 12A was $294,935. This is a cost reduction of $174,794, or 37.2%. Wow!!

From a financial standpoint, the only problem with 12A is that it's too efficient. Even when we charge $0.20 per lb. and make 44% margin, this is 44% of a much smaller sales number. Total gross profit dollars have increased only by 4%, from $225,524 to $235,047. The increasing profit from 12A will come from increased sales volume. With this 37% cost reduction, we can competitively price the product and increase our market share, sales volume, and profits.

JCA/jaz

cc: JHY
JAM

Bethlehem Burns Harbor
Comparison of Co-Injection and 12A
June 29 to September 22, 1997

	Magnesium Based 1996	Magnesium Based 1997	12A
Tons of Hot Metal Treated	309,656	309,656	309,656
Lbs of Magnesium	284,972	284,972	
Lbs of Lime	981,575	981,575	
Total Lbs 12A			2,649,908
Magnesium Cost per Lb.	$ 2.221	$ 1.450	
Lime Cost per Lb.	$ 0.055	$ 0.055	
12A Cost per Lb.			$ 0.109
Total Product Cost	$ 686,909	$ 467,196	$ 289,635
Freight	2,533	2,533	5,300
TOTAL COST	$ 689,443	$ 469,729	$ 294,935
TOTAL BILLING TO BETHLEHEM	$ 828,413	$ 695,253	$ 529,982
GROSS PROFIT	$ 138,970	$ 225,524	$ 235,047
	16.8%	32.4%	44.4%

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BETHLEHEM STEEL DEOXSULF 12A TRIAL

B12FMTD2	09/22/97		0.200 1.970	06/29/97	TO	09/22/97
	DEOXSULF 12 A	90-10	ALL HEATS	DEOXSULF 12 A	90-10	ALL HEATS
LADLES TREATED	7	17	24	1096	749	1845
TONS TREATED	1,991	4,823	6,814	309,656	212,758	522,414
AVERAGE TONS	284.4	283.7	283.9	282.5	284.1	283.2
AVERAGE START SULFUR	0.0276	0.0310	0.0300	0.0361	0.0438	0.0392
AVERAGE END SULFUR	0.0067	0.0035	0.0045	0.0086	0.0071	0.0080
AVERAGE AIM SULFUR	0.0081	0.0055	0.0063	0.0098	0.0077	0.0089
TURNDOWN AIM	0.0133	0.0106	0.0114	0.0154	0.0130	0.0145
TURNDOWN ACTUAL	0.0124	0.0093	0.0102	0.0112	0.0096	0.0106
TURNDOWN PICKUP	0.0057	0.0058	0.0058	0.0027	0.0026	0.0026
CONFORMANCE TO +.001 (1ST SHOTS)	85.71%	94.12%	91.67%	87.04%	81.31%	84.72%
ACTUAL POUNDS REAGENT @@	15,902	2,853	60,145	2,649,235	133,200	4,582,119
ACTUAL POUNDS PER TON	7.99	0.59		8.56	0.63	
DOLLARS 1ST SHOTS	$3,180.40	$14,278.41	$17,458.81	$525,585.30	$608,935.76	$1,134,521.06
REBLOW DOLLARS (INCLUDES AIM CHANGES)	$0.00	$190.60	$190.60	$19,237.72	$23,846.05	$44,306.74
TOTAL DOLLARS	$3,180.40	$14,469.01	$17,649.41	$544,823.02	$632,781.81	$1,178,827.80
DOLLARS PER TON 1ST SHOT	$1.60	$2.96	$2.56	$1.70	$2.86	$2.17
DOLLARS PER TON AFTER R.B.	$1.60	$3.00	$2.59	$1.76	$2.97	$2.26
ESTIMATED DOLLARS SAVED	**$736.82**	**($2,098.58)**	**($1,361.77)**	**$157,639.95**	**$11,676.34**	**$169,316.29**
ESTIMATED SAVINGS PER HEAT	**$105.26**	**($123.45)**	**($56.74)**	**$143.83**	**$15.59**	**$91.77**
*** PERCENT SAVINGS	**18.81%**	**-17.23%**	**-8.46%**	**23.24%**	**1.88%**	**13.07%**
START TEMPERATURE	2510	2503		2506	2457	
FINAL TEMPERATURE	2446	2477		2474	2430	
TEMPERATURE LOSS	64	27		32	27	
AVERAGE INJECTION TIME	11.40	13.32	12.76	13.48	14.37	13.84
AVERAGE SKIM WEIGHT		SCALE DOWN			SCALE DOWN	

@@ ALL HEATS SHOWS THE TOTAL AMOUNT OF 12A USED FOR BOTH PROCESSES.

*** SAVINGS IS CALCULATED BY COMPARING THE ACTUAL COST FOR THE TRIAL TO THE COST WHICH WOULD HAVE BEEN CHARGED USING THE COMPUTER REQUESTED AMOUNT OF 90-10 AND LIME AT A 3 TO 1 RATIO FOR THE LIME AND THE PRESENT REAGENT COSTS.

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MEMORANDUM OF UNDERSTANDING

Reactive Metals and Alloys Corporation ("Remacor") and USX Corporation ("USX") are assignees of rights in the Desulfurizing Mix and Method for Desulfurizing Molten Iron ("the Technology") that is the subject of United States Patent Application Serial No. 08/826,880 and Remacor and USX Engineers and Consultants Inc. ("UEC") are assignees of all corresponding rights in foreign countries. Remacor, UEC and USX desire to cooperate in licensing the Technology. Therefore, the parties agree as follows.

1. Remacor shall have the exclusive right to license the Technology in North America, Europe and the former Soviet Republics. As to all other countries either Remacor or UEC may pursue licensing opportunities.

2. Unless otherwise agreed, Remacor shall license the Technology based upon a royalty rate tied to the amount of desulfurizing mix used. The royalty rate and other terms of the license not mentioned herein shall be set by Remacor in its absolute discretion.

3. Remacor will pay UEC a royalty of ______ cents per pound of the Desulfurizing Mix sold by Remacor and its licensees except for sales by Remacor to existing customers as provided in Paragraph 6. Payments shall be made two months after each calendar quarter in which payment is received by Remacor.

4. Remacor shall report to UEC quarterly on the progress of its licensing efforts. The report shall include a copy of any license agreements signed since the previous report and a statement of royalties attributable to each license which has been signed.

5. UEC shall promptly notify Remacor of any licenses of the Technology or offers to license the Technology that it grants as permitted in Paragraph 1. Unless otherwise

agreed UEC shall pay Remacor one half of all royalty income received from licenses granted by UEC. Payments shall be made within two months of the receipt of such royalty income.

6. Neither USX nor its suppliers will pay any royalty for use of the Technology at any US Steel plant. Neither Remacor nor its customers will pay royalties for sales to and use of the Technology by Remacor's current customers.

7. Remacor and UEC shall consult and agree upon those foreign countries in which they wish to file foreign patent applications and equally share the patent expenses for the selected countries. If one party decides that it does not wish to pursue patent protection in a country the other party may do so at its own expense. The other party shall have no obligation to share royalties or license the party for that country in which that one party has decided not to pursue patent protection. In all circumstances the parties will cooperate with one another in signing papers, providing information and doing such other things as may be required to obtain patent protection.

8. In the event that any party discovers an infringer that party will notify the other parties of the suspected infringer. USX will then notify the suspected infringer of the infringement and demand that it either stop the infringement or obtain a license. If the suspected infringer continues the infringement then the parties will consult and decide what further action to take. If no agreement is reached any party may at its own expense file suit against the suspected infringer and receive all proceeds from the litigation. The other parties will cooperate in the litigation to the extent deemed necessary by trial counsel and be reimbursed for any out of pocket expenses incurred.

9. In the event that a potential licensee requests an indemnity against third party claims of infringement, the party receiving the request shall notify the other party. The parties shall agree upon a response and shall equally share all indemnification costs.

10. The licenses granted may include all improvements in the licensed invention arising out of use of the Technology. If so, it will be coupled with a grant back clause. If any party has or receives a patent on an invention that is not an improvement but is applicable to or useful in conjunction with the Technology that patent is not covered by this agreement. However, the party who receives such patent will notify the other parties of the receipt of the patent and the parties will negotiate whether that patent shall be offered or included within the licenses to the Technology.

11. If no United States Patent is granted from United States Patent Application Serial No. 08/826,880 or a continuation thereof, this agreement will be null and void.

12. Upon acceptance of these terms as stated or as here modified a formal agreement will be prepared.

ACCEPTED:

REACTIVE METALS & ALLOYS CORP.	USX CORPORATION	USX ENGINEERS and CONSULTANTS, INC.
By:__________	By:__________	By:__________
Date:__________	Date:__________	Date:__________

REMACOR
GROWTH OPPORTUNITIES

The U.S. steel industry over the last ten years has made a remarkable turnaround in terms of productivity, lower production costs and improved quality through modernization and technology. One of the technologies that the U.S. steel industry now uses is hot metal desulfurization. Without hot metal desulfurization, high quality steel cannot be produced. The U.S. now leads the world in this technology and REMACOR has been the pioneer and leader in the development of technology, equipment, products and service in this extremely important field.

One of the huge areas of growth for REMACOR is supplying hot metal desulfurization technology, know-how, equipment and products to the developing countries of Eastern Europe, the C.I.S. and China. Without this hot metal desulfurization technology, these countries will never develop the quality levels necessary in their steel plants to export products into the developed countries in North America or Western Europe. The exporting of raw steel from these developing countries is essential for the development of their economies. In most cases, domestic consumption of basic steel products is not sufficient to sustain economic viability or growth of the steel industry within these countries. Therefore, REMACOR is presently in great demand, worldwide, for their technology and equipment.

Another large area of potential growth is steel ladle products. The change from ingot casting to continuous casting in the steel industry required the steel industry to install ladle metallurgy furnaces (LMF) just prior to the continuous caster for the purpose of temperature control. The LMF, however, has also given the steelmakers another opportunity to do some last minute quality refining in the steel ladle that could not be possible at the basic steel making furnace (basic oxygen furnace). Presently, some steel producers are spending as much as $2.00 to $3.00 per ton for steel ladle treatment at the

LMF. Over the next five years, this market, with North America producing 100 million tons of steel per year, will grow to $200 to $300 million annually.

Again, REMACOR is the acknowledged leader in technology, but has not been able to make the capital investments required at their Gary, IN, Lindon, UT and Fort Erie, Ontario plants to capitalize on this rapidly-growing market. REMACOR is presently shipping about $8.0 million annually from its West Pittsburg plant. This represents only about 5% of the steel ladle products market in North America.

If adequately financed, the hot metal desulfurization market worldwide and the developing steel ladle market in North America over the next five years could enable REMACOR to grow to $150-200 million per year in annual sales

9/11/97

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NEWS RELEASE

TO:

FOR: IMMEDIATE RELEASE

DATE: May 11, 1993

NEWS ABOUT: REMACOR AND ALMAMET OF GERMANY TO FORM JOINT VENTURE IN EUROPE

REMACOR of West Pittsburg, Pennsylvania has announced they have formed a joint venture company with ALMAMET GmbH of Ainring, Germany to serve the European steel industry with magnesium-based hot metal desulfurization products and services as well as other metallurgical products, equipment and services. The joint venture company, ALMAMET-REMACOR GmbH will be located in Ainring.

ALMAMET was founded in 1983 and has a sales office in Ainring and manufacturing plants in Turkey and Germany. Their primary business is the production and sales of various grades of magnesium powders and magnesium-bearing desulfurization reagents.

ALMAMET, with their existing business operations, will handle sales and marketing, administration and all production activities for the new joint venture company. REMACOR's responsibilities will include technology, engineering, technical service and equipment supply.

It is presently proposed that ALMAMET-REMACOR GmbH will provide the "total package" concept to the European steel producers. The formation of this new company provides a new approach in Europe to hot metal desulfurization sales and other steel production related sales and service. The "total package" concept is where one company supplies technology, equipment, products and people to provide certain services to the steelmaker. REMACOR has pioneered this approach in hot metal desulfurization over the last ten years and has now become one of the largest companies in the U.S. supplying ladle metallurgy products and services to the steel industry.

The fall of Communism in the Eastern Bloc countries and in the former Soviet Union has created opportunities for companies like REMACOR and ALMAMET. The steel industry in these countries now has to dramatically improve the quality of its steel in order to compete and develop new markets in the western world. The technologies developed by REMACOR over the last ten years in hot metal desulfurization in North America are desperately needed by the steel producers in these countries if they are to survive and compete in the world market place.

For further information, please contact:

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ALMAMET

COMPANY PROFILE

Almamet was founded in 1983 by Ing. Eugen Wieser and Alexander Rhomberg with the goal of producing low cost Mg granules for the iron and steel industry in addition to the traditional products such as cuttings for the chemical industry and fine powders for the welding and pyrotechnical applications.

1985 the production plant came on stream. It is situated in the european part of Turkey. The current capacity of the plant is approx. 4.000 t/year of pure Mg products.

1986 an office in Istanbul was established and the first blending operation was installed in the Ruhr-area in Germany. The blending plant has a capacity of 4500 t of blends/year.

1993 a second blending operation was installed near Cologne, Germany. This plant is situated in a lime plant and prepares all lime based Mg blends. The capacity is approx. 6.000 t/year.

Almamet formed a joint venture company with Remacor Inc. New Castle PA, U.S.A.. Remacor is one of the leading companies in the world for lime based injection technology and desulfurization products. For over 15 years they have marketed these products in the U.S. and Canada. Amongst their customers are: Gary works, Weirton, Sharon, Wheeling Pit and McLaughlin in the U.S.A., and Dofasco and Stelco in Canada.
The JVC is called Almamet Remacor GmbH.

Beginning 1994 strong activities had been started in the CIS and Eastern Europe to promote desulfurization of hot metal using Magnesium. First results are an equipment supply contract with Nizni Tagil steelplant , signed in 1995.

Aso in 1995 a contract with the Slovenian calcium carbide producer Tovarna Dusika Ruse was signed, which enables Almamet to sell technical carbide and carbide blends.

In September 1995 Ing. Eugen Wieser retired and became a consultant to Almamet. The MINMET group, based in Lausanne, Switzerland, aquired his shares becoming a partner in Almamet.

In November 1995 a joint venture with SMW (Solikamsk Magnesium Works), Russia, was signed for the erection of a granule production plant in Solikamsk. The initial capacity will be 2.000 t/year with expansion possibilities up to 8.000 t/year

SPECTRUM of MAGNESIUM

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ALMAMET

In 1996 the market share of Almamet in Europe for high percentage Mg blends was 18 %, in Germany 25 %. We have continuous supply contracts with Thyssen, Krupp-Hoesch Stahl, Preussag Salzgitter, Dillingen in Germany, and Eregli and Iskenderun steelworks in Turkey. We are also a supplier to the swedish, british, japanese and french steelindustry. The market share for carbide based products in Germany has reached 25 %, in Europe 15%.

A new product for Almamet is granulated carbide for the desoxidation of slags in secondary metallurgy. The material is already supplied on a continuous basis to Brandenburg and Henningsdorf steelplants.

The consolidated turnover 1996 was 30,000,000 DM. The sale of Mg based blends was continuously increased from 100 t in 1985 to approx 4.000t expected this year. The sale of carbide based products has developed to an expected sales volume of 15.000 t this year.

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ALMAMET REMACOR

in cooperation with

EREĞLI IRON AND STEEL WORKS CO.

ERDEMİR

present

THE IV. INTERNATIONAL SYMPOSIUM FOR QUALITY IMPROVEMENT IN HOT METAL AND STEEL

<u>September 22-25, 1997 in Istanbul and Ereğli, Turkey</u>

PFE ORIGINAL

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THE IV.INTERNATIONAL SYMPOSIUM FOR QUALITY IMPROVEMENT IN HOT METAL AND STEEl
September 22-25,1997 ERDEMİR

LIST OF PARTICIPANTS

NAME	COMPANY	COUNTRY
İLHAN KOÇOĞLU	ERDEMİR	TURKEY
EROL ENGİN	ERDEMİR	TURKEY
AHMET MUTLUKOCA	ERDEMİR	TURKEY
NEVZAT YILDIZ	ERDEMİR	TURKEY
CEVDET BABAYİĞİT	ERDEMİR	TURKEY
MUSTAFA ULUSOY	ERDEMİR	TURKEY
İBRAHİM GÖL	ERDEMİR	TURKEY
ZİYA METİN USTA	ERDEMİR	TURKEY
EROL ÜNÜT	ERDEMİR	TURKEY
SADULLAH ŞENER	ERDEMİR	TURKEY
TEVFİK UZUN	ERDEMİR	TURKEY
NACİ ÇUBUK	ERDEMİR	TURKEY
DİLEK BAKAR	ERDEMİR	TURKEY
EMİN PARILDAR	ERDEMİR	TURKEY
MUSTAFA GÜNAY	ERDEMİR	TURKEY
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OKTAY ELKOCA	ERDEMİR	TURKEY
ŞERAFETTİN MEŞE	ERDEMİR	TURKEY
ATAMER GİYİCİ	ERDEMİR	TURKEY
FADIL DEMİREL	ERDEMİR	TURKEY
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OĞUZ TEMİZ	ERDEMİR	TURKEY
İSMAİL ERDOĞAN	ERDEMİR	TURKEY
OĞUZ ÖZGEN	ERDEMİR	TURKEY
TAYFUN GÜRSOY	ERDEMİR	TURKEY
ZAFER GÜLLE	ERDEMİR	TURKEY
HİMMET YAKAY	ERDEMİR	TURKEY
ŞEVKET EROL	ERDEMİR	TURKEY
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HASAN AKBULUT	ERDEMİR	TURKEY
UĞUR YILMAZ	ERDEMİR	TURKEY
YUSUF ÖZTÜRK	ERDEMİR	TURKEY
ZAFER İNANOĞLU	ERDEMİR	TURKEY
URAL DURUSU	ERDEMİR	TURKEY
FETHİ YEĞEN	ERDEMİR	TURKEY
RAMAZAN ÇELİK	ERDEMİR	TURKEY
BÜLENT ARSEVEN	ERDEMİR	TURKEY
MEHMET FİDAN	ERDEMİR	TURKEY
ŞAFAK ÇAPAR	ERDEMİR	TURKEY
HAKAN KÜNÜÇEN	ERDEMİR	TURKEY
ALTAN DEMİR	ERDEMİR	TURKEY
İBRAHİM TURAL	ERDEMİR	TURKEY
ERHAN SONVERDİ	ERDEMİR	TURKEY
EGEMEN ÇETEK	ERDEMİR	TURKEY
DAVUT ÇELİK	ERDEMİR	TURKEY

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NAME	COMPANY	COUNTRY
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HAKAN TANIK	ERDEMİR	TURKEY
TANER ERSOY	ERDEMİR	TURKEY
HALİL KARTAL	ERDEMİR	TURKEY
MEHMET AYDIN	ERDEMİR	TURKEY
KEMAL KÖROĞLU	ERDEMİR	TURKEY
SUAVİ BAYRAKTAR	ERDEMİR	TURKEY
SEZGİN ACUR	ERDEMİR	TURKEY
HİKRET ÇAĞLAYAN	ERDEMİR	TURKEY
ABDULKADİR ÖZDABAK	ERDEMİR	TURKEY
BEKİR SAKALLI	ERDEMİR	TURKEY
ŞEREF YILMAZ	ERDEMİR	TURKEY
ALİ AYDOĞAN	ERDEMİR	TURKEY
AHMET KEÇE	ERDEMİR	TURKEY
ORHAN GÜNGÖR	ERDEMİR	TURKEY
İBRAHİM KAYAHAN	ERDEMİR	TURKEY
ÖZKAN KAPTANOĞLUGİL	ERDEMİR	TURKEY
İSMAİL EMİN DÖNMEZ	ERDEMİR	TURKEY
HAYRETTİN İNAL	ERDEMİR	TURKEY
KEMAL ERKUT	ERDEMİR	TURKEY
VEDAT KOÇAK	ERDEMİR	TURKEY
SERDAR ERTAN	ERDEMİR	TURKEY
ÜNAL HALICI	ERDEMİR	TURKEY
ERDAL ŞENTÜRK	ERDEMİR	TURKEY
MEHMET GÜRSES	ERDEMİR	TURKEY
FUAT ALA	ERDEMİR	TURKEY
BENGÜ ATEŞLİ	ERDEMİR	TURKEY
CENGİZ ŞAHİNTÜRK	ERDEMİR	TURKEY
NURETTİN GÜLTEKİN	ERDEMİR	TURKEY
ABDULLAH GÜNDÜZ	ERDEMİR	TURKEY
RACİ GÖKTAŞ	ERDEMİR	TURKEY
OĞUZ GÜNDÜZ	ERDEMİR	TURKEY
MELİH KOÇ	ERDEMİR	TURKEY
GÖKHAN ERDEM	ERDEMİR	TURKEY
EROL BAŞ	ERDEMİR	TURKEY
ERSİN ERÜNSAL	ERDEMİR	TURKEY
MEMDUH EMEKÇİ	ERDEMİR	TURKEY
ÖZLEM BAYDAR	ERDEMİR	TURKEY
MALİK BIYIKLI	ERDEMİR	TURKEY
CEMAL YILDIRIM	ERDEMİR	TURKEY
MELDA ŞAHİN	ERDEMİR	TURKEY
TANER AYDIN	ERDEMİR	TURKEY
TUNCA ÖZENCİ	ERDEMİR	TURKEY
OSMAN YAZAROĞLU	ERDEMİR	TURKEY
BAKİ GÜLTEKİN	ERDEMİR	TURKEY
MEHMET KAHRAMAN	ERDEMİR	TURKEY
SAYGUN GÖNEY	ERDEMİR	TURKEY
İBRAHİM TOZLU	ERDEMİR	TURKEY
AHMET TAŞKIN	ERDEMİR	TURKEY
TUNCAY ÇALIŞKAN	ERDEMİR	TURKEY
ALİ ERDOĞAN	ERDEMİR	TURKEY
ABDÜLKADİR AYDIN	ERDEMİR	TURKEY
A.NECİP EBEGİL	İSDEMİR	TURKEY
SANİ ERALP	İSDEMİR	TURKEY
İSMAİL BARIN	İSDEMİR	TURKEY
ALİ OSMAN KILIÇ	İSDEMİR	TURKEY
NÜVİT KAYA	İSDEMİR	TURKEY

PFE ORIGINAL

NAME	COMPANY	COUNTRY
ERDAL GÜNDÜZ	İSDEMİR	TURKEY
FİRDEVSİ ARIKAN	İSDEMİR	TURKEY
ÖMER ÖZALP	İSDEMİR	TURKEY
RECEP ÜNAL	İSDEMİR	TURKEY
DOĞAN YİĞİT	İSDEMİR	TURKEY
YAVUZ DEVECİLER	İSDEMİR	TURKEY
ÖZCAN KIRAN	KARDEMİR	TURKEY
SEMİH ESEN	KARDEMİR	TURKEY
LÜTFULLAH ÜNAL	KARDEMİR	TURKEY
MANSUR YEKE	KARDEMİR	TURKEY
ERDAL ÜNGÖREN	KARDEMİR	TURKEY
GAMZE BAHAROĞLU	KARDEMİR	TURKEY
ASİL SAVRAN	KARDEMİR	TURKEY
ZEYNEP TAHİROĞLU	MME	TURKEY
ERDEM DEMİRCAN	MME	TURKEY
BEHÇET CANAY	MMD	TURKEY
ERDAL ALİSBAH		TURKEY
EKREM SELÇUK	Middle East Technical University	TURKEY
THOMAS DAUM	VOEST ALPINE	AUSTRIA
GERHARD HUBMER	VOEST ALPINE	AUSTRIA
STEFAN TEUBEL		AUSTRIA
DRAGOMIR DAKOV	UEP BULGARIAN BRANCH	BULGARIA
PETR LEVICEK	MATECS	CZECH R.
LADISLAV ZELA	NOVA HUT AS	CZECH R.
MILAN MACOSZEK	VITKOVICE AS	CZECH R.
GRAHAM WARDLOW	MAGNESIUM ELEKTRON	ENGLAND
BARTLOMIET WYDRA	PECHINEY	FRANCE
REGIS SZEZESNY	VALPROSID	FRANCE
EUGEN WIESER	ALMAMET GMBH	GERMANY
ALEXANDER RHOMBERG	ALMAMET GMBH	GERMANY
RUDOLF GEISLER	ALMAMET GMBH	GERMANY
GERTRAUD MITTERREITER	ALMAMET GMBH	GERMANY
RAINER WENZEL	ALMAMET GMBH	GERMANY
PETER SCHWEIZER	ALUMA GMBH	GERMANY
ALFRED FREISSMUTH		GERMANY
MATTHIAS SITTARD	SIMET GMBH	GERMANY
ANDREAS ECHELMEIER	THYSSEN -KRUPP-STAHL	GERMANY

PFE ORIGINAL

NAME	COMPANY	COUNTRY
ALESSANDRO DE CESARE	ILVA	ITALY
WERNER SCHWARZ	C.E. GIULINI	ITALY
JENS CHR. BORKE	ODDA SMELTEVERK	NORWAY
ANDRZEJ SZEJA	POLSIN KARBID	POLAND
IGNAT GHEORGE-SORIN	CARBID FOX	ROMANIA
MARIA BALI	CARBID FOX	ROMANIA
RUXANDRA IONESCU	IPROMET	ROMANIA
GRIGORY M. GULAYEV	ORSK CHALILOVO IRON+STEEL WORKS	RUSSIA
MR. BABIN	ORSK CHALILOVO IRON+STEEL WORKS	RUSSIA
JURY A. BODYAEV	MAGNITOGORSK IRON+STEEL WORKS	RUSSIA
OLEG A. NIKOLAEV	MAGNITOGORSK IRON+STEEL WORKS	RUSSIA
SERGUEI ZINTCHENKO	SEVERSTAL IRON+STEEL WORKS	RUSSIA
VALERY VYDRIN	SOLIKAMSK DESULFURIZATION WORKS	RUSSIA
EFIM BORODULIN		RUSSIA
ANATOLY IOVIK		RUSSIA
PETER I. YUGOV	ZNIITSCHERMET	RUSSIA
ALEXANDR A. FETISOV	NIZHNY TAGIL IRON+STEEL WORKS	RUSSIA
VLADIMIR A. SHESTOPEROV	NIZHNY TAGIL IRON+STEEL WORKS	RUSSIA
VALERIJ N. MINEJEV	NIZHNY TAGIL IRON+STEEL WORKS	RUSSIA
VENCE TINTA	SALONIT ANHOVO	SLOVENIA
VENCESLAV STANIC	SALONIT ANHOVO	SLOVENIA
TATJANA KUNST	TDR METALLURGIJA	SLOVENIA
JENS NYLANDER	CASCO PRODUCTS AB	SWEDEN
HERMAN SCHILLERWEIN	ECKART SWITZERLAND	SWITZERLAND
DMYTRY A. DYUDKIN	UEP DONETZK	UKRAINE
BRUCE GWYNNE	READE MANUFACTURING	USA
BRIAN M. KINSMAN	REMACOR	USA
JOSEPH R. JACKMAN	REMACOR	USA
JAMES H. YOUNG	REMACOR	USA
THOMAS BIENIOSEK	ROSSBOROUGH	USA
GERALD R. ZEBROWSKI	ROSSBOROUGH	USA

PFE ORIGINAL

POTENTIAL GROWTH OVER THE NEXT 10 YEARS IN DESULFURIZATION IN W. EUROPE, E. EUROPE, C.I.S AND CHINA

North America (Total Desulfurization Technology)

Total Hot Metal Production	-	62.3 Million MT
Magnesium Used in Desulfurization	-	29,000 MT
Total Size of Market	-	$160 Million
Cost Per Ton of Hot Metal	-	$2.57/MT

Western Europe, Eastern Europe, C.I.S. and China (Only W. Europe uses Desulf. Tech.)

Total Hot Metal Production E. Europe	-	21.5 Million MT
Total Hot Metal Production C.I.S.	-	57.7 Million MT
Total Hot Metal Production China	-	50.0 Million MT
Total Hot Metal Production W. Europe	-	97.8 Million MT
Total Hot Metal Production	-	227.0 Million MT

Magnesium Presently Used in Desulf.	-	17,600 MT
Potential Growth in Magnesium Market	-	106,000 MT

Potential Growth in Size of Market:

$98 Million ⟶ $583 Million

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PFE ORIGINAL

Primary Iron Production, 1989-1996

(thousand metric tons)

	1989	1990	1991	1992	1993	1994	1995	1996 P	%96/95
Austria	3,823	3,452	3,442	3,074	3,070	3,320	3,878	3,416	-11.9
Belgium	8,862	9,416	9,353	8,524	8,179	8,979	9,199	8,627	-6.2
Finland	2,284	2,283	2,331	2,452	2,535	2,597	2,242	2,457	9.6
France	14,725	14,096	13,408	12,730	12,335	12,917	13,154	12,402	-5.7
F.R. Germany	32,113	29,585	30,608	28,201	26,705	29,632	30,038	27,722	-7.7
Italy	11,761	11,852	10,845	10,451	11,187	11,159	11,663	10,322	-11.5
Luxembourg	2,684	2,645	2,463	2,255	2,412	1,927	1,028	829	-19.4
Netherlands	5,163	4,960	4,696	4,849	5,404	5,443	5,530	5,544	0.2
Spain	5,479	5,441	5,397	4,758	5,394	5,447	5,106	4,127	-19.2
Sweden	2,638	2,736	2,812	2,735	2,845	3,037	3,020	3,130	3.6
United Kingdom	12,638	12,319	11,883	11,542	11,534	11,943	12,238	12,838	4.9
Total E.U. (15)	102,547	99,124	97,489	91,973	91,998	96,817	97,510	91,835	-5.8
Switzerland	141	129	105	102	82	80	80	80 E	0.0
Turkey	4,037	5,367	4,154	5,059	4,931	4,604	4,403	5,253	19.3
Total W. Europe	109,863	106,987	103,075	97,716	97,146	101,593	102,171	97,803	-4.3
Bulgaria	1,487	1,143	960	848	1,013	1,470	1,607	1,504	-6.4
Czechoslovakia	9,911	9,667	8,479						
Czech Republic				5,082	4,655	5,268	5,274	4,898	-7.1
German D.R.	2,722	2,128	1,111						
Hungary	1,957	1,711	1,311	1,176	1,407	1,595	1,515	1,496	-1.3
Poland	9,075	8,352	6,297	6,316	6,105	6,735	7,420	6,581	-11.3
Romania	9,052	6,355	4,525	3,111	3,189	3,495	4,203	4,058	-3.4
Slovak Republic				2,952	3,205	3,330	3,207	2,930	-8.6
Total E. Europe	34,259	29,396	22,693	19,488	19,575	21,893	23,226	21,468	-7.6
Kazakhstan				4,659	3,544	2,435	2,592	2,536	-2.2
Russia				45,990	40,766	36,480	39,145	37,046	-5.4
Ukraine				35,162	27,022	20,084	17,904	18,155	1.4
Total C.I.S.				85,811	71,332	58,999	59,641	57,737	-3.2
Georgia				242					
Total Former U.S.S.R.	113,273	110,167	90,953	86,053	71,332	58,999	59,641	57,737	-3.2
Canada	10,139	7,346	8,267	8,621	8,633	8,106	8,464	8,638	2.1
Mexico	3,230	3,665	2,962	3,404	3,423	3,501	4,142	4,240	2.4
United States	50,687	49,668	44,123	47,377	48,155	49,374	50,902	49,376	-3.0
Total N. America	64,056	60,679	55,353	59,402	60,211	60,981	63,508	62,254	-2.0
Argentina	2,169	1,933	1,305	966	984	1,389	1,568	1,966	25.3
Brazil	24,363	21,141	22,695	23,152	23,982	25,177	25,090	24,121	-3.9
Chile	679	675	703	873	917	886	855	996	16.5
Colombia	297	323	305	308	238	245	282	288	2.2
Paraguay	61	54	68	92	81	90	103	103	-0.1
Peru	209	93	207	145	201	200	247	273	10.6
Total S. America	28,233	24,533	25,284	25,536	26,404	27,987	28,146	27,748	-1.4
Algeria	1,315	1,054	877	930	925	919	940	800 E	-14.9
Egypt	1,105	1,093	1,204	1,062	1,326	1,148	1,062	1,050 E	-1.1
South Africa	6,543	6,257	6,968	6,498	6,121	6,047	6,224	6,014	-3.4
Tunisia	155	161	172	158	165	154	162	145	-10.2
Zimbabwe	525	521	535	507	211	150	205	219	6.6
Total Africa	9,643	9,086	9,756	9,155	8,748	8,419	8,593	8,228	-4.2

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PFE ORIGINAL

Primary Magnesium Shipments (in metric tons)
1st Quarter 1997

Area of Use: Category:	Area 1 U.S. & Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa & Mid-East	Area 5 Asia/ Oceanic	TOTAL
Al. Alloying						
a. producers	15,400	200	6,000	300	3,400	25,300
b. CIS/PRC	1,600	600	1,900	700	4,500	9,300
c. sub-total	17,000	800	7,900	1,000	7,900	34,600
Nodular Iron						
a. producers	1,500	100	400	---	100	2,100
b. CIS/PRC	200	---	200	---	500	900
c. sub-total.	1,700	100	600	---	600	3,000
Desulfurization						
a. producers	4,400	---	2,100	---	---	6,500
b. CIS/PRC	2,800	---	2,300	200	200	5,500
c. sub-total	7,200	---	4,400	200	200	12,000
Metal Reduction						
a. producers	800	---	300	---	---	1,100
b. CIS/PRC	200	---	---	---	---	200
c. sub-total	1,000	---	300	---	---	1,300
Electro-Chemical						
a. producers	1,000	200	100	---	100	1,400
b. CIS/PRC	---	---	200	---	100	300
c. sub-total	1,000	200	300	---	200	1,700
Chemical						
a. producers	300	---	700	---	600	1,600
b. CIS/PRC	---	---	---	---	300	300
c. sub-total	300	---	700	---	900	1,900
Die Casting						
a. producers	15,600	600	3,800	---	800	20,800
b. CIS/PRC	1,100	---	300	---	300	1,700
c. sub-total	16,700	600	4,100	---	1,100	22,500
Gravity Casting						
a. producers	200	---	400	---	---	600
b. CIS/PRC	---	---	---	---	---	---
c. sub-total	200	---	400	---	---	600
Wrought Prdcts.						
a. producers	600	---	---	---	100	700
b. CIS/PRC	---	---	---	---	---	---
c. sub-total	600	---	---	---	100	700
Other						
a. producers	800	---	100	---	100	1,000
b. CIS/PRC	300	---	100	---	100	500
c. sub-total	1,100	---	200	---	200	1,500
TOTAL						
a. producer	40,600	1,100	13,900	300	5,200	61,100
b. CIS/PRC	6,200	600	5,000	900	6,000	18,700
c. **Grand Total**	**46,800**	**1,700**	**18,900**	**1,200**	**11,200**	**79,800**

(Note: The data for the exports of primary magnesium by the Commonwealth of Independent States and the Peoples' Republic of China has been estimated by the primary producer participants in the IMA statistics program. Beginning with the 4th Quarter of 1993, casting scrap tolled by the primary producers has been reported by them in both production and shipments.)

PFE ORIGINAL

OPPORTUNITIES TO SELL MAGNESIUM POWDER PRODUCTION TECHNOLOGY IN CHINA

The Chinese have virtually no magnesium powder production capability and no company in the western world is willing to sell equipment or technology to China.

In view of REMACOR's new desulfurization technology requiring no magnesium; the opportunity to sell magnesium powder production technology to approximately six to eight primary magnesium ingot producers over the next two to three years is very good.

Presently there is approximately 47,000 MT of magnesium powder consumed in the world and that figure could grow to 150,000 MT or approximately $500 million.

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PFE ORIGINAL

SEPTEMBER 1997

China Magnesium

Metal Bulletin Books, Ltd., has recently published CHINESE METALS DIRECTORY. As far as is known, it is the most comprehensive directory of Chinese non-ferrous metal producers and traders to be published outside of China. Professor Wen Lu, of the Chengdu Institute of Technology in Sichuan, gathered most of the information largely from the companies themselves.

The directory lists 26 primary producers of magnesium with a combined stated capacity of 47,850 tonnes. The two largest, Fushun Aluminum at 5,400 tonnes and Minhe Magnesium Works at 4,000 tonnes, are both owned by China National Non-

China Mag. Directory

continued from page 1

Ferrous Industrial Corporation (a government agency). Six plants are listed with stated capacities of 3,000 to 3,500 tonnes, twelve at 1,000 to 2,000 and six at less than 1,000 tonnes. Potential expansion plans reported by four of the producers in 1996 totaled 16,100 tonnes.

The directory also lists three powder producers, two sheet and strip, one extruder and one secondary smelter. The directory is available from Metal Bulletin Books, Ltd., Park House, Park Terrace, Worcester Park, Surrey, KT4 7HY, United Kingdom for U.S. $243. The price for residents of the U.K. is 125 pounds sterling and 129 pounds for the rest of Europe.

PFE ORIGINAL

TECHNOLOGY AND EQUIPMENT PURCHASE AGREEMENT

THIS AGREEMENT made this 19th day of September, 1997, by and between REACTIVE METALS & ALLOYS CORPORATION, with offices at P.O. Box 366, Route 168, West Pittsburg, Pennsylvania 16160, U. S. A. ("REMACOR"), and HUAQI MAGNESIUM INDUSTRY COMPANY, LTD/CHINA NATIONAL METAL PRODUCTS IMPORT/EXPORT COMPANY with offices at, Tiexi Industry District in Qixian County, Henan Province, China (hereinafter "BUYERS");

W I T N E S S E T H:

WHEREAS, REMACOR has proprietary magnesium powder production technology and know-how, and can supply magnesium powder production equipment and associated engineering services and;

WHEREAS, BUYERS has agreed to purchase and REMACOR has agreed to sell certain magnesium powder production equipment and associated engineering services and proprietary technology and know-how, on the terms and conditions herein set forth;

NOW THEREFORE, the parties hereto agree as follows:

A. GRANT OF TECHNOLOGY.

1.1 The term "Technology," as used herein, includes (a) all engineering drawings, equipment lists, equipment specifications, safety, operating and maintenance manuals, and engineering instructions delivered by REMACOR to BUYERS pursuant hereto, (b) the design and operating characteristics of all machinery and equipment supplied in connection herewith, and (c) all other technical information communicated, whether orally or in writing, by REMACOR to BUYERS pursuant to this Agreement, and identified by REMACOR as part of its proprietary technology.

1.2 REMACOR hereby grants to BUYERS in perpetuity the exclusive right, license and privilege to use the Technology at its plant in China in which the equipment sold hereunder is located, or in any location in China to which all or substantially all of such equipment may subsequently be moved and installed.

1.3 REMACOR warrants that it owns the Technology and has full right, power and authority to grant the Technology to BUYERS hereunder.

1.4 REMACOR will transfer the Technology to BUYERS by delivering to BUYERS as soon as they are completed, which is anticipated to be within approximately sixty (60) days after the signing of this Agreement, (a) engineering drawings, as described in more detail on

Exhibit A hereto, for the magnesium powder production equipment layout and installation at BUYERS's magnesium production facility, (b) equipment lists, complete with all equipment identification and specifications, and (c) all operating, safety and maintenance manuals required for the operation, safety and maintenance of the magnesium powder production facility to be installed by BUYERS. REMACOR shall not be responsible for translating any of the documentation into Chinese.

1.5 REMACOR will send Plan and Elevation drawings for the purpose of determining building design requirements as soon as possible but no later than fourteen (14) days from the signing of this Agreement.

B. SALE OF EQUIPMENT.

2.1 REMACOR shall sell and BUYERS shall purchase the equipment listed on Exhibit B hereto (the "Equipment"), together with complete equipment identification and specifications, and a spare parts list.

2.2 REMACOR shall have the Equipment packaged and ready for shipment from West Pittsburg within approximately ninety (90) days from the date of this Agreement.

C. RESPONSIBILITIES OF BUYERS AND REMACOR.

3.1. BUYERS shall, at its expense, make some modifications to an existing building or construct a new building, in accordance with general arrangement drawings supplied by REMACOR, for installation of the Equipment. REMACOR will not supply detailed drawings of building. BUYERS shall complete the required modifications to an existing building or construct a new building by approximately the time the Equipment arrives in China.

3.2 BUYERS shall install and supply all electrical conduit, electrical wiring, control wiring, electrical starters and electrical breakers at its expense, per REMACOR's engineering instructions. BUYERS shall complete the electrical work by approximately the time the Equipment arrives in China.

3.3 BUYERS shall supply all needed labor for installation of the Equipment in its building, at its own expense.

3.4 REMACOR will guarantee the equipment sold to the BUYERS for the commercial production capacity as designed per the drawings and technology.

3.5 REMACOR agrees to purchase and supply additional spare parts or other supplies required for the magnesium grinding operation for the BUYERS at invoice price plus 10% for handling and administration.

D. TECHNICAL ASSISTANCE.

4.1 REMACOR will supply technical assistance in the form of one engineering supervisor, who will oversee the equipment installation phase, the start-up phase and the training of BUYERS's operating personnel at BUYERS's facility in China. It is anticipated that the services of the engineering supervisor may be required for up to four (4) months. The scheduling of the period of residency in China for REMACOR's engineering supervisor shall be as agreed from time to time by REMACOR and BUYERS.

4.2 REMACOR will bear the cost of the engineering supervisor for a total of ninety (90) days. If BUYERS require the presence of an engineering supervisor for more than ninety (90) days, there will be a charge of $500.00 per day for each day spent in China. REMACOR will rotate as many as three engineering supervisors in order to minimize the total time each supervisor has to spend away from home. REMACOR will be responsible for all expenses traveling to and from China. The Buyers will be responsible for all travel, lodging and meals for the supervisors while they are in China. The Buyers shall supply interpreting services as required.

E. PAYMENT.

5.1 Payment shall be made in U.S. Dollars. BUYER shall secure four (4) individual irrevocable letters of credit in favor of REMACOR from an acceptable bank in the full amount of the contract prices listed in paragraphs 5.3, 5.4, 5.5 and 5.6. The letters of credit shall conform to the specifications set forth in Joseph R. Jackman's letter of September 16, 1997 which is attached as Exhibit C and becomes a part of this contract.

5.2 The Contract Price is USD 1,200,000.00, composed of USD 250,000.00 for engineering services, USD 250,000.00 for Technology, and USD 700,000.00 for the Equipment.

5.3 10 % of the Contract Price, USD 120,000.00, is due and payable on the signing of this Agreement. This amount will be credited against the technology fee and engineering fees.

5.4 A total of USD 360,000.00 (30%), shall be due and payable on shipment of the engineering drawings, the equipment lists, complete with proper equipment identification and specifications, and all operating, safety and maintenance manuals.

5.5 USD 600,000.00 (50%) shall be due and payable on shipment of the Equipment by REMACOR to China.

5.6 The balance of the purchase price, USD 120,000.00 (10%), shall be due and payable upon completion of the installation and start-up phases of the new magnesium powder production facility, when the Equipment is operational for commercial production and a system capable of a production rate of 4800 MTPY or five (5) pounds per minute per hammermill of a minus 20 mesh magnesium powder is achieved in a continuous operation and is so acknowledged by both parties in writing.

F. SAFETY.

6.1 REMACOR warrants that the equipment sold by it hereunder shall meet the specifications of REMACOR, and that it will convey good title to the Technology and the Equipment to BUYERS free from any lawful encumbrance. REMACOR DISCLAIMS ANY OTHER EXPRESS OR IMPLIED WARRANTIES. BUYERS's exclusive remedy and REMACOR's total liability for claims of breach of warranty hereunder shall be limited to repair or replacement of, or repayment of the purchase price paid for, the goods supplied hereunder with respect to which damages are claimed. BUYERS waives all other claims against REMACOR, including specifically any claims for incidental, consequential, special, or punitive damages.

6.2 BUYERS expressly acknowledges that magnesium powder is hazardous, flammable and explosive. BUYERS agrees to indemnify and hold REMACOR harmless from any loss, liability, expense or damage to BUYERS, its employees, agents, workers, independent contractors, or any other third party arising from BUYERS's handling or use of the Equipment, the Technology, or its magnesium powder production facility.

G. CONFIDENTIALITY.

7.1 "Confidential Information," as used herein, includes all Technology delivered to BUYERS pursuant hereto, excluding, however, any information which:

(a) prior to the disclosure of such information (i) was in the public domain or (ii) was in BUYERS's possession as documented by competent proof, or

(b) after disclosure of such information (i) becomes part of the public domain by publication or otherwise by or through parties other than BUYERS, or (ii) is acquired by BUYERS from a third party which is lawfully in possession of such information and not in violation of any contractual, legal or fiduciary obligation to REMACOR with respect thereto.

7.2 BUYERS agrees that it will not sublicense the Confidential Information, that it will not use the Confidential Information except in the operation at one location of the Equipment sold hereunder, and that it will not disclose to any third party any of the Confidential Information without the prior written consent of REMACOR. In particular, BUYERS agrees that it will not duplicate or attempt to duplicate the ingot grinding machines sold hereunder, nor will it permit its employees, agents or representatives, to attempt to duplicate such machines nor communicate to others the confidential information required to do so.

7.3 The obligations of confidentiality of BUYERS hereunder shall extend for as long as BUYERS uses any portion of the Confidential Information in the operation of the Equipment or of a magnesium powder production facility, and for five years thereafter.

H. **FORCE MAJEURE.**

8.1 In the event of a war, fire, explosion, flood, strike, accident, action of governmental authority, or other contingency beyond the reasonable control of REMACOR or BUYERS, interfering with the performance by either party of its duties hereunder, the party so affected shall be relieved of its duties hereunder for the period of such force majeure, but this agreement shall be otherwise unaffected.

I. **MISCELLANEOUS.**

9.1 All payments hereunder are to be made in U.S. dollars as outlined in Section E, paragraph 5.1, and all Equipment is sold F.O.B. West Pittsburg and is to be packed in wooden crates for seaworthy transportation.

9.2 This contract is subject to the export control laws and regulations of the United States and the import control laws and regulations of China.

9.3 This Agreement is not assignable by either party, except to an affiliated company which acquires substantially all of the assets of REMACOR's West Pittsburg manufacturing facility or BUYERS's magnesium production facility, respectively, and which assumes the obligations of the assignor hereunder.

9.4 All notices and requests under this Agreement shall be in writing and shall be deemed delivered when received by the party to which given, or at the address of such party as set forth in the recitals hereto, or at such changed address of which either party shall have given notice to the other.

9.5 This Agreement shall be governed by and interpreted under the laws of the Commonwealth of Pennsylvania and of the United States.

9.6 Lief International (USA) Inc. has assisted in the negotiations of both parties to reach this agreement.

J. QUALITY DISCREPANCY AND CLAIM.

10.1 In case a quality discrepancy is found by the BUYERS to be not in conformity with the Agreement after arrival of the goods at the port of destination, the BUYERS may lodge claim with REMACOR supported by survey report issued by an inspection organization agreed upon by both parties, with the exception, however, of those claims for which the Insurance Company and/or the shipping company are to be held responsible. Claim for quality discrepancy should be filed by the BUYERS within 30 days after arrival of the goods at the port of destination. REMACOR shall, within 30 days after receipt of the notification of the claim, send reply to the BUYERS.

K. WARRANTY PROVISIONS.

11.1 The product built and furnished by REMACOR hereunder is warranted to be free from defects in workmanship and material under normal use and service for a period of fifteen (15) months from the date such product is shipped to purchaser or twelve (12) months from the date such product is placed into service, whichever is the longer time period. In case any such defect develops, BUYERS shall send to REMACOR at its office in West Pittsburg, Pennsylvania, prompt written notice thereof, together with satisfactory proof of such defect. Upon receipt of such notice, REMACOR shall have the option of repairing or replacing the defective part or parts at its factory in West Pittsburg, Pennsylvania, or at BUYERS' plant. BUYERS shall return the defective part or parts, freight paid by REMACOR. When it is not possible to ship such part or parts, REMACOR will repair or replace the defective merchandise at BUYERS' plant. A new warranty period shall not be established for repaired or replaced material. Such items shall remain under warranty only for the remainder of the original warranty period.

The foregoing constitutes the complete and exclusive liability of REMACOR with respect to any breach or warranty. In no event shall REMACOR be liable for any consequential damages resulting from defective goods delivered hereunder, or for any loss of profit or production, loss of time to the use, to goods in process, or for any labor or other expense, damage or loss occasioned by any defective goods delivered hereunder. Liability shall in no event exceed the furnishing of replacement material plus payment for freight as above provided, and shall not extend to or include the cost of dismantling the defective part or parts or the installation of the replacement material.

This warranty shall not apply to normal wear and tear, consumable parts nor to any part or parts which shall have been altered or repaired without REMACOR's knowledge and written consent nor to any part or parts which have been subject to misuse, abuse, neglect or accident.

REMACOR makes no warranty whatsoever with respect to any accessory equipment not manufactured by it. and such equipment is sold "AS IS". Any guarantees or warranties on accessory equipment furnished by outside manufacturers shall to the fullest extent possible, be transferred to BUYERS for its benefit and REMACOR will assist BUYERS in the vigorous pursuit thereof. The warranty set forth herein is expressly in lieu of all other warranties of REMACOR, expressed or implied, statutory, by operation of law, and no other warranty is made or created by this document or by any other agreement between REMACOR and BUYERS, and there are no warranties which extend beyond the description contained herein, and BUYERS expressly waives all other warranties and agrees to accept the goods "as is", other than as specifically set forth above. REMACOR neither assumes. nor authorizes any other person to assume for it, any other warranty or liability for its product.

L. ARBITRATION.

12.1 All disputes, controversies or differences which may arise between the parties out of, or in connection with this contract shall be settled amicably. However, should an amicable settlement not be reached within three (3) months, the dispute shall be finally settled under the Rules of Conciliation and Arbitration of the International Chamber of Commerce by one or more of the arbitrators appointed in accordance with the said Rules. Swiss law (Schweizerisches Oblligationinrecht) shall be applied. The decision will be final and binding on both parties. Both parties undertake to fulfill the decision voluntarily. The parties to this agreement agree to have recourse if necessary, to the International Chamber of Commerce (ICC) in accordance with the ICC's Rules for Technical Expertise.

M. LANGUAGE.

13.1 This Agreement was originally prepared in the English language, and BUYERS have caused a Chinese language translation of this Agreement to be prepared. The parties agree that they will promptly engage a mutually acceptable law firm to review the English and Chinese versions of this Agreement and give its opinion to the parties that the two versions set forth the same business transaction and the same agreements of the parties with the same binding legal effect on each party. In the event such law firm determines that there is a discrepancy between the two versions, the Chinese version shall be corrected to conform to the English version unless REMACOR otherwise agrees. The fee of such law firm, which shall be borne by BUYERS.

IN WITNESS WHEREOF, the parties have signed as of the day and year first above written.

REACTIVE METALS & ALLOYS CORPORATION

By: ______________________
Joseph R. Jackman, President

HUAQI MAGNESIUM INDUSTRY COMPANY, LTD.

By: ______________________
Wang Yunquan

CHINA NATIONAL METAL PRODUCTS IMPORT/EXPORT COMPANY

By: ______________________
[illegible]

LIEF INTERNATIONAL (USA) Inc.

By: ______________________
Xie Lu

PFE ORIGINAL

REMACOR

P.O. Box 366, Route 168
West Pittsburg, PA 16160
(412) 535-4357
FAX: (412) 535-7761

EXHIBIT A

ENGINEERING DRAWINGS

2	Plan
3	Elevation
11	Ingot Cutter
8	Primary and Secondary Hammermills
1	Screw Conveyor
4	Cyclone
2	Oversized Return Blower System
2	Screen
3	Main Blower System
3	Oversized Return
2	Control
9	Electrical
50	Total drawings required. Will be in metric system.

PFE ORIGINAL

REMACOR

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West Pittsburg, PA 16160
(412) 535-4357
FAX: (412) 535-7761

EXHIBIT B

EQUIPMENT

	Quantity	Item
1.	2	Ingot cutting machines with indexer
2.	2	Primary hammermills and 75 HP explosion-proof motors, each
3.	4	Secondary hammermills with screens and 100 HP explosion-proof motors, each
4.	2	Main 5000 CFM blowers and 25 HP explosion-proof motors
5.	4	Duct magnets
6.	2	Cyclone collectors
7.	2	48", 2-deck stainless screens with 2½ HP explosion-proof motors
8.	2	Oversized return blowers, 1½ HP
9.		Required 16 gauge steel duct
10.	6	Closed circuit television cameras
11.	2	Control consoles
12		Spare parts:
	8	Screens for HM
	3 sets	Hammers for each HM
	5 sets	Cutters for each ingot cutting machine

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EXHIBIT C

PFE ORIGINAL

REMACOR

P.O. Box 366, Route 168
West Pittsburg, PA 16160
(412) 535-4357
FAX: (412) 535-7761

Office of the President

VIA UPS OVERNIGHT MAIL

September 16, 1997

Mr. Xie Lu
Lief International (USA) Inc.
One World Trade Center
Suite 2133
New York, NY 10048

RE: Details on Letters of Credit

Dear Mr. Xie:

Pertaining to our sale of magnesium technology, engineering services and equipment to your company, it will be necessary for you to secure four individual irrevocable letters of credit, from an acceptable bank, with the following terms and conditions:

Beneficiary: Reactive Metals & Alloys Corporation (REMACOR)
P.O. Box 366, Route 168
West Pittsburg, PA 16160, USA
Attention: John C. Amer or Charles Willison
Telephone: (412) 535-4357
Fax: (412) 535-7761

Beneficiary's Bank: Core States
Philadelphia National Bank
Terri Pacan, Account Administrator
National Commercial Finance Unit
FCI-8-4-26
1339 Chestnut Street
Philadelphia, PA 19107 USA
Account #2002-4456
Telephone: (215) 973-7662
Fax: (215) 973-2633

"It's Performance That Counts"

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Total Amount of The Four Letters of Credit:	$1,200,000.00 US Dollars
Description of Goods and Services Covered under the Letters of Credit:	Magnesium Powder Production Equipment Magnesium Technology Engineering Services

Partial Shipments are Permitted.

Terms of Shipment: F.O.B. Shipping Port

Insurance on equipment in transit will be paid for by the BUYERS.

All bank charges outside the United States of America are to be paid by the BUYERS.

Terms of the Letters of Credit draws will be as follows:

Letter of Credit #1 10% of the Contract Price, USD 120,000.00, is due and payable on the signing of this Agreement. BUYERS will supply to the Bank, a letter stating the contract was signed.
Expiration Date: September 30, 1997

Letter of Credit #2 30% of the Contract Price, USD 360,000.00, shall be due and payable on shipment of the engineering drawings, the equipment lists, complete with proper equipment identification and specifications, and all operating, safety and maintenance manuals. The Seller will supply to the bank, a copy of the Federal Express or UPS receipt verifying shipment.
Expiration Date: October 15, 1997

Letter of Credit #3 50% of the Contract Price, USD 600,000.00, shall be due and payable on shipment of the Equipment. The Seller shall supply to the Bank an original invoice, an original bill of lading and a full set of shipping documents.
Expiration Date: December 31, 1997

Letter of Credit #4 10% of the Contract Price, USD 120,000.00, shall be due and payable upon completion of the installation and start-up phases of the new magnesium powder production facility, when the Equipment is operational for commercial production and a system capable of a production rate of 4800 MTPY or five (5)

PFE ORIGINAL

pounds per minute per hammermill of a minus 20 mesh magnesium powder is achieved in a continuous operation and is so acknowledged by both parties in writing. A letter signed by both the SELLER and the BUYERS will be forwarded to the bank.

Expiration Date: June 30, 1998

Should you need any additional information, please contact John Amer or Charles Willison.

Sincerely,

REMACOR

Joseph R Jackman

Joseph R. Jackman
President

JRJ/mjl
JRJ483.DOC

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REMACOR

P.O. Box 366, Route 168
West Pittsburg, PA 16160
(412) 535-4357
FAX: (412) 535-7761

REMACOR

UNITED STATES PATENTS

No.	Patent No.	Patent Description	Date Issued
1	4,022,444	Apparatus for Adding Mischmetal to Molten Steel - J. R. Jackman	May 10, 1977
2	4,052,202	Zirconium Alloy Additive and Method for Making Zirconium Additions to Steels - L. Luyckx	October 4, 1977
3	4,060,407	Methods and Apparatus for Adding Mischmetal to Molten Steel - J. R. Jackman	November 29, 1977
4	4,142,887	Steel Ladle Desulfurization Compositions and Methods of Steel Desulfurization - L. Luyckx	March 6, 1979
5	4,279,643	Magnesium Bearing Compositions for and Method of Steel Desulfurization - J. R. Jackman	July 21, 1981
6	4,279,650	Titanium Bearing Addition Alloys - J. R. Jackman and W. E. Hanna	July 21, 1981
7	4,311,523	Titanium-Boron Additive Alloys - L. Luyckx	January 19, 1982
8	4,956,009	Calcium Alloy Steel Additive and Method Thereof - J. W. Robison	September 11, 1990
9	5,021,086	Iron Desulfurization Additive and Method for Introduction into Hot Metal - L. A. Luyckx, J. R. Jackman, J. W. Robison, J. H. Young	June 4, 1991
10	5,188,661	Dual Port Lance and Method - Donald R. Cook, Joseph A. Macri	February 23, 1993
11	5,658,367	Method of Manufacturing Magnesium Powder from Magnesium Crown - Joseph R. Jackman, Leon A. Luyckx, Jeffrey S. Gill	August 19, 1997
12		Desulfurizing Mix and Method for Desulfurizing Molten Iron - Brian Kinsman, Leon Luyckx, James Young, Jr., Robert Branion, Jr.	Application filed April 7, 1997

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